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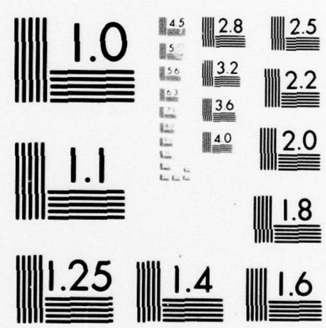

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A GEOMETRIC METHOD OF CONSTRUCTING AN IMAGE RECOVERED FROM SURFACE HOLOGRAMS

by

V. I. Mandrosov

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А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α	α	α	Nu	Ν	ν	
Beta	Β	β		Xi	Ξ	ξ	
Gamma	Γ	γ		Omicron	Ο	ο	
Delta	Δ	δ		Pi	Π	π	
Epsilon	Ε	ε	ϵ	Rho	Ρ	ρ	ϱ
Zeta	Ζ	ζ		Sigma	Σ	σ	ς
Eta	Η	η		Tau	Τ	τ	
Theta	Θ	θ	ϑ	Upsilon	Υ	υ	
Iota	Ι	ι		Phi	Φ	φ	ϕ
Kappa	Κ	ϰ κ	ϰ	Chi	Χ	χ	
Lambda	Λ	λ		Psi	Ψ	ψ	
Mu	Μ	μ		Omega	Ω	ω	

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A GEOMETRIC METHOD OF CONSTRUCTING AN IMAGE RECOVERED FROM SURFACE HOLOGRAMS

V. I. Mandrosov

In [1] we used a wave approach to the theory of holograms located on nonplanar surfaces. On the other hand, the author of [2] examined a geometric method of constructing an image recovered from plane holograms in the paraxial region. The purpose of the present communication is to generalize this method to the case of off-axis nonplanar holograms of arbitrary form.

To analyze the geometric properties of nonplanar surface holograms, let us introduce the coordinate system (x, y, z) with its origin at the apex of a hologram and with axis z directed along the normal to the apex.

Let us also introduce the following designations: $\vec{r}_1(x_1,y_1,z_1)$ - coordinates of a point on the object; $\vec{R}_1(X_1,Y_1,Z_1)$ - coordinates of the source of the reference signal; $\vec{r}_2(x_2,y_2,z)$ - coordinates of the observation point; $\vec{R}_2(X_2,Y_2,Z_2)$ - coordinates of the source of the recording signal; $k_1 = 2\pi/\lambda_1$ - wave number of the reference-signal source; $k_2 = 2\pi/\lambda_2$ - wave number of the recording-signal source; $\vec{r}(x,y,z)$ - coordinates of the point on the hologram, where $z = z(x,y)$ is the equation of the surface on which the hologram is located.

Then, in Fresnel approximation the diffraction zone that forms the imaginary and real image of the point of the object can be represented in the form [1]:

$$E = \frac{i\exp i\psi(0,0)}{r_2\lambda_2}\int\exp i\Big[\psi_x'(0,0)x + \psi_y'(0,0)y + \\ + \frac{1}{2}\psi''_{xx}(0,0)x^2 + x\psi''_{xy}(0,0)y + \frac{1}{2}\psi''_{yy}(0,0)y^2\Big]dx\,dy, \quad (1)$$

where $\psi(x,\ y) = k_1|\vec{r}_1 - \vec{r}|k_1|\vec{R}_1 - \vec{r}| + k_2|\vec{R}_2 - \vec{r}| - k_2|\vec{r}_2 - \vec{r}|$ **is the total phase of the field.**

Let us divide the hologram into small segments with origins in **coordinates** $x_m, y_n, z_{mn} = z(x_m, y_n)$ **and make a substitution of variables** $x = x_m + s,\ y = y_n + t$.

Then, in the vicinity of the mn-th segment, the field from the point on the object, provided that

$$\frac{1}{2}\psi''_{xx}(0,0)s^2+\psi''_{xy}(0,0)st+\frac{1}{2}\psi''_{yy}(0,0)t^2<\frac{\pi}{8} \qquad (2)$$

can be represented in the form

$$E=\frac{1}{r_2\lambda_2}\int \exp i\,[(\psi_x'(0,0)+\psi''_{xx}(0,0)x_m+\psi''_{xy}(0,0)y_n)s+ + (\psi_y'(0,0)+\psi''_{yy}(0,0)y_n+x_m\psi''_{xy}(0,0))\,t]\,ds\,dt$$

(the nonessential phase factors are not considered here).

Thus, with observation of condition (2) the total phase of the field ψ in the vicinity of the mn-th segment is a linear function of s and t, i.e., of the coordinates of the point on the hologram.

Starting with this fact, we can show that for a given segment the recording and restoration process occurs just as for a Frauenhofer hologram. Such a hologram is formed with the restoration of two quasi-planar beams located, as easily shown, with respect to beam S_2L passing from the reconstructing source at the same angle as that at which the reference source S_1 and the corresponding point O_1 on the object are seen from the mn-th segment [3] (see the figure).

Constructing the restored quasi-planar beams in two such segments and continuing these beams until they intersect, we can construct two images of point O_1 of the object: the imaginary O_2^+ and real O_2^- images. When part of the hologram is located on the path

of, or even near, the line connecting reference source S_1 with the point on the object O_1, one of the segments is conveniently selected at the intersection P of this line with the hologram (or, mentally, on the intersection with the extension of the hologram), as shown in the figure.

In this case the contribution to the distribution function on this segment from the point on the object will be virtually constant, and the beams that participate in forming the image of the given point will pass in the same direction as the beam from the reconstructing source to the given segment [2] (beam S_2P in the figure).

Thus, knowing the position of the reference and reconstructing sources we can construct an image of the object, restored over the surface of a nonplanar hologram. We can show, in this case, that the position of the restored images coincides in the paraxial region with the position of the image calculated using the Kirchhoff principle. Consequently, the geometric method is applicable primarily in the paraxial region.

Motion Picture Scientific Research Institute (NIKFI)

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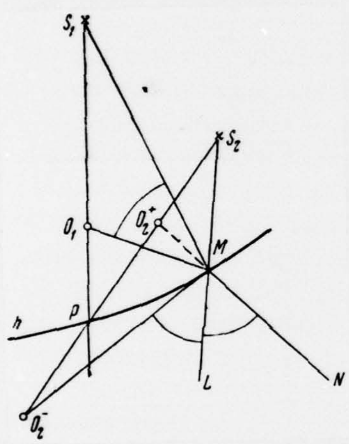

Figure caption

Geometric construction of imaginary and real images, restored over a curvilinear hologram: S_1 - reference source; S_2 - reconstructing source; h - hologram. $\angle S_1MO_1 = \angle O_2^-ML = \angle LMN$.

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